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ABSTRACT: The results of testing dry anticoagulant baits at the Animal Biology Laboratory are evaluated in this paper. Overall, 14,940 rats were committed to these tests resulting in a mortality rate of 91.8 percent. The five chemicals tested and their mean mortality per test are: Diphacinone (93.5 percent), Pival (87.5 percent), Warfarin (93.9 percent), Prolin (91.2 percent), and Fumarin (92.8 percent).

The data indicates that 77.4 percent of the tests conducted resulted in a mortality of 90 percent or greater, but only 11.9 percent of them resulted in acceptance of 33 percent or greater and mortality of 90 percent or greater.

INTRODUCTION

The purpose of this paper is to tabulate the results of 747 rat bioassays conducted since 1968. The sample size and procedure are identical in every test. Tests conducted prior to 1968 are not reported here because test methodology was not identical to present methods.

All anticoagulant baits tested were interstate samples and were intended for commercial sale. Before reaching E.P.A.'s Animal Biology Laboratory at Beltsville, Maryland, all samples were analyzed at an E.P.A. chemical product laboratory.

The data reported in this paper is not intended to endorse or reject the efficacious nature of any bait form or toxicant. Although all poison baits were shipped to the laboratory from virtually all states to be bioassayed for acceptance and mortality, not all formulations on the market were sampled and consequently the results of these tests can only roughly be considered a reflection of all anticoagulant baits in general.

Chemicals tested and reported upon in this paper are:

Diphacinone: (2-diphenylacetyl-1,3-indandione).
Pival: (2-pivalyl-1,3-indandione).
Warfarin: [3-(alpha-acetonylbenzyl)-hydroxycoumarin].
Prolin is warfarin plus sulfaquinoxaline [N^1-(2-quinoxaly)-sulfanilamide].
Fumarin: [3-(alpha-acetonyl-furfuryl)-4-hydroxycoumarin].

MATERIALS AND METHODS

All tests were conducted with approximately 50-day old Wistar strain albino laboratory rats (Rattus norvegicus). Ten males and ten females were used for each test. Rats were individually housed in an open-top suspended wire cage (20 x 25 x 18 centimeters). All food was offered to the rats in aluminum feeding cups, nine centimeters in diameter (4.5 centimeters deep). The anticoagulant treated food and the standard E.P.A./T.S.D. laboratory diet were offered in separate cups in excess of the daily food requirements (over 30 grams each). The gross weight of each food was determined daily and returned to the starting weight. Weights were recorded to the nearest gram. The cage position of the bait and the standard laboratory diet cups was reversed every 24 hours to counteract any feeding position habit of the rat. All rats were given free-choice between treated and untreated food.

The standard E.P.A./T.S.D. laboratory diet consists of 65 percent animal feed grade corn meal, 25 percent steamed rolled oats, five percent corn oil, and five percent sugar. The diet is ground fine enough so the rats cannot pick out the oats from the corn meal, and yet has a particle size larger than flour. Mixing is conducted in a twin shell blender.

*Reference to trade names does not imply endorsement of commercial products by the Federal Government. It is for identification only. All of the products referred to in this paper are manufactured domestically and/or imported and there has been no distinction made between them.

Records were kept on the daily food intake, mortality, weight, and sex of individual animals under test. The test product was available for 15 consecutive days or until 100 percent mortality.

After 15 days of testing, survivors were held for five additional days with standard laboratory diet ad libitum to determine delayed mortality.

RESULTS

The results of bioassays of Diphacinone, Pival, Warfarin, Prolin, and Fumarin are presented in Tables 1 through 5, respectively, and are summarized collectively in Table 6. Each Table is divided into three sections (A, B, and C). Section A is concerned with the number of deaths per test with measurements of both central tendency and dispersion. Section B tabulates the total test days the rats survived per test. This essentially measures rapidity of kill. A rat that survives the entire tests adds 20 to the total. The maximum possible survival days are 400 (20 rats x 20 days = 400). In actual practice, the highest total on any test was 391 survival days (one rat died on the 11th day of the test and the other 19 survived).

The "C" Tables illustrate bait acceptance. Acceptance is expressed in terms of bait refusal (percentage of total food intake which was unpoisoned). This follows the same style and thought of Hayes and Gaines (1959).

Each of the tables are divided into bait form: (1) whole grain (grains are either hulled or left intact and not mechanically altered; (2) meal (usually a combination of grain either crushed or rolled and blended into a homogeneous mixture); (3) pellet (meal compacted into a spherical or flattened shape; and (4) wax block (cereals and whole grains coated with wax). Included in this group are the paraffinized pellets.

AMOUNT OF "KILL" PER ANTICOAGULANT CHEMICAL

Considering the 747 tests together, 14,940 rats were committed and 13,713 (91.8 percent) of them succumbed to effects attributed to the anticoagulants. The mean mortality per 20 rat test by chemical is: (1) Diphacinone 18.7 (93-5 percent); (2) Pival 17.5 (87.5 percent); (3) Warfarin 18.8 (93.9 percent); (4) Prolin 18.2 (91.2 percent); and (5) Fumarin 18.6 (92.8 percent). (Tables 1A through 6A.) The statistical significance of the percent deaths of any anticoagulant as compared to others in all possible combinations is presented in Table 7. Whereas the sample sizes in most cases are large, the slight differences in mortality per test is significant. However, all chemicals, except Fumarin, are also statistically significant in average kill per test when compared to the compendium (average of all chemicals together). The results of Fumarin baits and the collective average of all the anticoagulants together are very similar.

RAPIDITY OF KILL

Although the time of death is recorded at 24-hour intervals, the procedure is consistent and there is an adequate sample size, a fairly accurate determination of the "rapidity of kill" can be determined.

Rats bioassayed with Warfarin baits averaged fewer survival days per test (159.5) than any of the other anticoagulants (Tables IB through 6B).

PERCENT OF BAIT REFUSAL

Pival baits had the better acceptance (Tables 1C through 6C) than any of the other chemicals tested with a mean bait refusal of 73.5 percent. The mean percent bait refusal for the other anticoagulants tested were Diphacinone 76.5 percent, Warfarin 79.4 percent, Prolin 80.4 percent, and Fumarin 76.6 percent.

RESULTS WITH A BAIT REFUSAL OF LESS THAN 67 PERCENT AND A MORTALITY OF 90 PERCENT OR MORE

Twenty-six percent of the Pival baits bioassayed had a kill of at least 90 percent with a bait refusal of less than 67 percent (Tables 1C through 6C). Fourteen percent of the Diphacinone, nine percent of the Warfarin, ten percent of the Prolin, ten percent of the Fumarin, and 11.9 percent of 89 out of 747 baits tested overall passed the above criteria.

Table 1A. Toxic effects of Diphacinone baits upon albino rats offered simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Deaths						Tests 90% Kill or Above	
		$\bar{x}$/Test*	Percent	Range	S.D.**	P 50†	95% Confidence Limit for $\bar{x}$	Number	Percent
Whole Grain	0	-	-	-	-	-	-	-	-
Meal	39	18.4	92.0	(9-20)	2.00	19.0	± 0.63	31	79.5
Pellet	6	19.5	97.5	(18-20)	0.83	20.0	± 0.66	6	100.0
Wax Block	60	18.8	94.0	(14-20)	1.51	19.0	± 0.38	49	81.7
Summary	105	18.7	93.5	(9-20)	1.69	19.0	± 0.32	86	81.9

* Twenty rats per test (ten males, ten females). ** Standard deviation. † Median.

Table 1B. Length of survival of albino rats offered a Diphacinone bait simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Survival Days					$\bar{x}$ Test Days Per Rat
		$\bar{x}$/Test*	Range	S.D.**	P 50†	95% Confidence Limits for $\bar{x}$	
Whole Grain	0	-	-	-	-	-	-
Meal	39	166.2	(129-295)	29.9	160.0	± 9.38	8.3
Pellet	6	144.2	(130-163)	12.4	142.0	± 9.92	7.2
Wax Block	60	174.8	(111-268)	29.5	174.0	± 7.46	8.7
Summary	105	169.8	(111-295)	29.73	169.0	± 5.69	8.5

* Total test days survived by 20 rats (maximum would be 400, 20 rats x 20 days). ** Standard deviation. † Median.

Table 1C. Acceptance of Diphacinone baits by albino rats offered simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Percent Bait Refusal*					Bait Refusal Less Than						67% & 90% or > Mortality	
							67%		75%		90%			
		$\bar{x}$/Test*	Range	S.D.**	95% Confidence Limits for $\bar{x}$	P 50†	No.	%	No.	%	No.	%	No.	%
Whole Grain	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Meal	39	73.5	(52.6-92.7)	9.2	± 2.91	76.9	8	21	17	44	38	97	7	18
Pellet	6	65.3	(54.8-71.4)	7.1	± 5.68	68.4	2	33	6	100	6	100	2	33
Wax Block	60	78.3	(55.7-89.5)	8.2	± 2.08	80.4	6	10	19	32	60	100	6	10
Summary	105	76.5	(52.6-92.7)	8.8	± 1.69	76.9	16	15	42	40	104	99	15	14

* Acceptance is expressed in terms of bait refusal (percentage of total food intake which was unpoisoned). ** Standard deviation.
† Median.

Table 2A. Toxic effects of Pival baits upon albino rats offered simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Deaths						Tests 90% Kill or Above	
		$\bar{x}$/Test*	Percent	Range	S.D.**	P 50†	95% Confidence Limit for $\bar{x}$	Number	Percent
Whole Grain	0	-	-	-	-	-	-	-	-
Meal	52	17.2	86.0	(4-20)	3.25	19.0	± 0.88	32	61.5
Pellet	19	18.2	91.0	(13-20)	2.46	19.0	± 1.11	13	68.4
Wax Block	1	20.0	100.0	0	0	0.0	0.00	1	100.00
Summary	72	17.5	87.5	(4-20)	3.07	19.0	± 0.71	46	63.9

* Twenty rats per test (ten males, ten females). ** Standard deviation. † Median.

Table 2B. Length of survival of albino rats offered a Pival bait simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Survival Days					
		$\bar{x}$/Test*	Range	S.D.**	P 50†	95% Confidence Limits for $\bar{x}$	$\bar{x}$ Test Days Per Rat
Whole Grain	0	-	-	-	-	-	-
Meal	52	184.7	(119-280)	54.2	167.5	± 14.7	9.2
Pellet	19	167.1	(118-231)	41.1	160.0	± 12.6	8.4
Wax Block	1	136.0	-	-	-	-	6.8
Summary	72	179.4	(118-280)	46.91	165.0	± 10.8	9.0

* Total test days survived by 20 rats (maximum would be 400, 20 rats x 20 days). ** Standard deviation. † Median

Table 2C. Acceptance of Pival baits when offered simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Percent Bait Refusal*					Bait Refusal Less Than						67% & 90% or > Mortality	
							67%		75%		90%			
		$\bar{x}$/Test*	Range	S.D.**	95% Confidence Limits for $\bar{x}$	P 50†	No.	%	No.	%	No.	%	No.	%
Whole Grain	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Meal	52	75.3	(34.4-93.0)	13.3	± 3.6	76.8	10	19	22	42	48	92	10	19
Pellet	19	69.5	(35.2-89.0)	17.7	± 8.0	71.1	8	42	9	47	19	100	8	42
Wax Block	1	55.9	-	-	-	-	1	100	1	100	1	100	1	100
Summary	72	73.5	(34.4-93.0)	14.8	± 3.4	74.0	19	26	32	44	68	94	19	26

* Acceptance is expressed in terms of bait refusal (percentage of total food intake that was unpoisoned). ** Standard deviation.
† Median.

Table 3A. Toxic effects of Warfarin baits upon albino rats offered simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Deaths						Tests 90% Kill or Above	
		$\bar{x}$/Test*	Percent	Range	S.D.**	P 50†	95% Confidence Limit for $\bar{x}$	Number	Percent
Whole Grain	1	20.0	100.0	-	-	-	-	1	100.0
Meal	105	18.6	93.2	(5-20)	3.10	20.0	± 0.59	82	78.1
Pellet	49	19.0	95.2	(13-20)	1.64	20.0	± 0.45	40	81.6
Wax Block	2	19.0	95.0	(18-20)	1.41	19.0	-	2	100.0
Summary	157	18.8	93.9	(5-20)	2.25	20.0	± 0.35	125	79.6

* Twenty rats per test (ten males and ten females). ** Standard deviation. † Median.

Table 3B. Length of survival of albino rats offered a Warfarin bait simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Survival Days					
		$\bar{x}$/Test*	Range	S.D.**	P 50†	95% Confidence Limits for $\bar{x}$	$\bar{x}$ Test Days Per Rat
Whole Grain	1	125.0	-	-	-	-	6.3
Meal	105	161.0	(107-340)	42.9	153.0	± 8.2	8.1
Pellet	49	156.0	(95-237)	30.2	153.0	± 8.5	7.8
Wax Block	2	178.0	(170-186)	11.3	178.0	± 15.7	8.9
Summary	157	159.5	(95-340)	37.1	153.0	± 5.8	8.0

* Total test days survived by 20 rats (maximum would be 400, 20 rats x 20 days). ** Standard deviation. † Median.

Table 3C. Acceptance of Warfarin baits by albino rats offered simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Percent Bait Refusal*					Bait Refusal Less Than						67% & 90% or > Mortality	
							67%		75%		90%			
		$\bar{x}$/Test*	Range	S.D.**	95% Confidence Limits for $\bar{x}$	P 50†	No.	%	No.	%	No.	%	No.	%
Whole Grain	1	87.0	-	-	-	-	0	0	0	0	1	100	0	0
Meal	105	81.8	(58.1-98.9)	11.5	± 2.20	82.6	5	5	23	22	89	85	4	4
Pellet	49	74.1	(52.0-91.0)	10.3	± 2.88	73.3	10	20	27	55	47	96	10	20
Wax Block	2	77.8	(75.6-80.0)	3.1	± 4.30	77.8	0	0	0	0	2	100	0	0
Summary	157	79.4	(52.0-98.9)	9.6	± 1.50	79.5	15	10	50	32	139	89	14	9

* Acceptance is expressed in terms of bait refusal (percentage of total food intake which was unpoisoned. ** Standard deviation.
† Median.

Table 4A. Toxic effects of Prolin baits upon albino rats offered simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Deaths						Tests 90% Kill or Above	
		$\bar{x}$/Test*	Percent	Range	S.D.**	P 50†	95% Confidence Limits for $\bar{x}$	Number	Percent
Whole Grain	5	20.0	100.0	0	0	20.0	-	5	100.0
Meal	146	18.1	90.3	(1-20)	3.00	19.0	± 0.49	113	77.4
Pellet	169	18.1	90.7	(8-20)	2.14	19.0	± 0.32	131	77.5
Wax Block	1	18.0	90.0	-	0	18.0	-	1	100.0
Summary	321	18.2	91.2	(5-20)	2.56	19.0	± 0.27	250	77.9

* Twenty rats per test (ten males, ten females). ** Standard deviation. † Median.

Table 4B. Length of survival of albino rats offered a Prolin bait simultaneously with standard laboratory diet.

Bait Form	Number of Tests	Survival Days					
		$\bar{x}$/Test*	Range	S.D.**	P 50†	95% Confidence Limits for $\bar{x}$	$\bar{x}$ Test Days Per Rat
Whole Grain	5	133.4	(114-141)	11.1	138.0	± 9.7	6.7
Meal	146	169.2	(109-391)	46.1	161.5	± 7.5	8.5
Pellet	169	170.3	(121-316)	32.9	168.0	± 5.0	8.5
Wax Block	1	187.0	0	0	187.0	0	9.4
Summary	321	169.3	(109-391)	39.3	165.5	± 4.3	8.5

* Total test days survived by 20 rats (maximum would be 400, 20 rats x 20 days). ** Standard deviation. † Median.

Table 4C. Acceptance of Prolin baits by albino rats offered simultaneously with standard laboratory diet.

Bait Form	Number of Tests	Percent Bait Refusal*					Bait Refusal Less Than						67% & 90% or > Mortality	
							67%		75%		90%			
		$\bar{x}$/Test*	Range	S.D.**	95% Confidence Limits for $\bar{x}$	P 50†	No.	%	No.	%	No.	%	No.	%
Whole Grain	5	72.5	(68.2-80.6)	5.2	± 4.6	69.6	0	0	4	80	5	100	0	0
Meal	146	81.6	(43.4-99.2)	11.6	± 1.9	84.5	18	12	34	23	109	75	18	12
Pellet	169	79.8	(44.5-94.7)	8.6	± 1.3	81.3	14	8	42	25	146	86	14	8
Wax Block	1	83.2	0	0	-	83.2	0	0	0	0	1	100	0	0
Summary	321	80.4	(43.4-99.2)	10.1	± 1.10	82.4	32	10	80	25	261	81	32	10

* Acceptance is expressed in terms of bait refusal (percentage of total food intake which was unpoisoned). ** Standard deviation.
† Median.

Table 5A. Toxic effect of Fumarin treated bait upon albino rats when offered simultaneously with standard laboratory diet.

Bait Form	Number of Tests	Deaths						Tests 90% Kill or Above	
		$\bar{x}$/Test*	Percent	Range	S.D.**	P 50†	95% Confidence Limits for $\bar{x}$	Number	Percent
Whole Grain	0	-	-	-	-	-	-	-	-
Meal	45	18.3	91.4	(14-20)	1.87	19.0	± .55	31	68.9
Pellets	44	18.8	94.1	(14-20)	1.32	19.0	± .39	37	84.1
Wax Block	3	18.7	93.3	(18-20)	1.51	18.0	± 1.4	3	100.0
Summary	92	18.6	92.8	(14-20)	1.61	19.0	± .32	71	77.2

* Twenty rats per test (ten males, ten females). ** Standard deviation. † Median.

Table 5B. Length of survival of albino rats offered a Fumarin bait simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Survival Days					
		$\bar{x}$/Test*	Range	S.D.**	P 50†	95% Confidence Limits for $\bar{x}$	$\bar{x}$ Test Days Per Rat
Whole Grain	0	-	-	-	-	-	-
Meal	45	176.2	(118-251)	37.0	172.0	± 10.81	8.8
Pellets	44	157.7	(106-219)	20.9	156.0	± 6.18	7.9
Wax Block	3	179.0	(152-198)	24.0	187.0	± 27.16	9.0
Summary	92	167.5	(106-251)	31.1	163.0	± 6.36	8.4

* Total test days survived by 20 rats (maximum would be 400, 20 rats x 20 days). ** Standard deviation. † Median.

Table 5C. Acceptance of Fumarin baits by albino rats offered simultaneously with a standard laboratory diet.

Bait Form	Number of Tests	Percent Bait Refusal*					Bait Refusal Less Than						67% & 90% or > Mortality	
							67%		75%		90%			
		$\bar{x}$/Test*	Range	S.D.**	95% Confidence Limits for $\bar{x}$	P 50†	No.	%	No.	%	No.	%	No.	%
Whole Grain	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Meal	45	80.1	(64.5-98.2)	8.83	± 2.58	81.4	3	7	16	36	38	84	3	7
Pellet	44	72.7	(53.7-88.8)	6.89	± 2.03	72.5	6	14	26	59	44	100	6	14
Wax Block	3	82.6	(80.2-85.8)	2.86	± 3.17	81.9	0	0	0	0	3	100	0	0
Summary	92	76.6	(64.5-98.2)	8.65	± 1.77	76.5	9	10	42	46	85	92	9	10

* Acceptance is expressed in terms of bait refusal (Percentage of total food intake which was unpoisoned). ** Standard deviation.
† Median.

Table 6A. Toxic effect of anticoagulant baits upon albino rats when offered simultaneously with a standard laboratory diet.*

Bait Form	Number of Tests	Deaths						Tests 90% Kill or Above	
		$\bar{x}$/Test**	Percent	Range	S.D.†	P 50††	95% Confidence Limits for $\bar{x}$	Number	Percent
Whole Grain	6	20.0	100.0	0	0	20.0	0	6	100.0
Meal	387	18.2	90.8	(17.2-18.6)	2.74	19.0	± 0.27	289	74.7
Pellets	287	18.5	92.5	(18.1-19.5)	1.98	19.0	± 0.23	227	79.1
Wax Block	67	18.8	93.8	(18.0-20.0)	1.46	19.0	± 0.36	56	83.6
Summary	747	18.4	91.8	(17.2-20.0)	2.37	19.0	± 0.17	578	77.4

* Compilation of Tables 1A through 5A. Chemicals tested are Diphacinone, Pival, Warfarin, Prolin, and Fumarin.
** Twenty rats per test (ten males, ten females). † Standard deviation. †† Median.

Table 6B. Length of survival of albino rats offered an anticoagulant treated bait simultaneously with a standard laboratory diet.*

Bait Form	Number of Tests	Survival Days					$\bar{x}$ Test Days Per Rat
		$\bar{x}$/Test**	Range	S.D.†	P 50††	95% Confidence Limits for $\bar{x}$	
Whole Grain	6	132.0	(114.0-141.0)	10.5	137.0	± 8.38	6.6
Meal	387	169.6	(161.5-184.7)	42.9	169.2	± 4.27	8.5
Pellet	287	165.2	(144.2-170.3)	31.8	165.0	± 3.68	8.2
Wax Block	67	174.7	(136.0-187.0)	28.7	175.0	± 6.87	8.7
Summary	747	168.1	(114.0-187.0)	38.0	160.0	± 2.73	8.4

* Compilation of Tables 1B through 5B. Chemicals tested are Diphacinone, Pival, Warfarin, Prolin, and Fumarin.
** Total test days survived by 20 rats (maximum would be 400, 20 days x 20 rats). † Standard deviation. †† Median.

Table 6C. Acceptance of anticoagulant baits by albino rats offered simultaneously with a standard laboratory diet.*

Bait Form	Number of Tests	Percent Bait Refusal**					Bait Refusal Less Than						67% & 90% or > Mortality	
							67%		75%		90%			
		$\bar{x}$/Test**	Range	S.D.†	95% Confidence Limits for $\bar{x}$	P 50††	No.	%	No.	%	No.	%	No.	%
Whole Grain	6	74.9	(72.5-87.0)	7.5	± 5.36	79.7	0	0	4	67	6	100	0	0.0
Meal	387	80.0	(75.3-81.8)	10.8	± 1.08	80.1	44	11	112	29	322	83	42	10.9
Pellet	287	76.8	(65.3-80.1)	10.2	± 1.18	72.7	40	14	110	38	262	91	40	13.9
Wax Block	67	78.3	(55.9-83.2)	8.3	± 1.99	77.8	7	11	20	29	67	100	7	10.5
Summary	747	78.6	(55.9-87.0)	10.5	± 0.75	79.5	91	12	246	33	657	88	89	11.9

* Compilation of Tables 1C through 5C. Chemicals tested are Diphacinone, Pival, Warfarin, Prolin, and Fumarin.
** Acceptance is expressed in terms of bait refusal (percentage of total food intake which was unpoisoned).
† Standard deviation. †† Median.

Table 7. Significance levels for five anticoagulant rodenticides in all possible combinations. Statistical significance is computed from Tables 1A through 6C. Values indicated for mean mortality differences per test are chi square with Yates correction, and days and percent bait refusal are Z* (large sample method). Chi square values over 3.84 and Z values over 1.96 are significant to five percent level.

	Deaths Per Test (x^2 values)				
Chemical	Compendium	Fumarin	Prolin	Warfarin	Pival
Diphacinone	5.76	0.40	11.30	0.56	35.39
Pival	31.18	26.01	16.24	54.13	-
Warfarin	15.51	2.18	24.05	-	-
Prolin	3.95	5.78	-	-	-
Fumarin	2.00	-	-	-	-

	Survival Days Per Test (Z values)				
Chemical	Compendium	Fumarin	Prolin	Warfarin	Pival
Diphacinone	0.53	0.56	0.17	2.49	1.54
Pival	1.98	1.86	1.70	3.17	-
Warfarin	2.63	1.82	2.66	-	-
Prolin	0.46	0.46	-	-	-
Fumarin	0.17	-	-	-	-

	Percent Bait Refusal (Z values)				
Chemical	Compendium	Fumarin	Prolin	Warfarin	Pival
Diphacinone	2.23	0.08	3.80	2.52	1.54
Pival	2.86	1.58	3.77	3.11	-
Warfarin	0.93	2.37	1.06	-	-
Prolin	2.64	2.74	-	-	-
Fumarin	1.62	-	-	-	-

* Alder and Roessler, 1964.

Table 8. Chi Square tabular values with Yates correction for five anticoagulants in all possible combinations. The first group is the significance of the proportional number of tests per anticoagulant that have a bait refusal of less than 67 percent and a mortality of 90 percent or more. The second group is the significance of the proportional difference in the number of tests that have a mortality of 90 percent or more. Chi Square values of 3.84 or more are significant to at least the five percent level.

	67 Percent or Less Bait Refusal, 90 Percent or More Mortality				
Chemical	Compendium	Fumarin	Prolin	Warfarin	Pival
Diphacinone	0.287	0.56	1.10	1.34	3.29
Pival	10.79	6.74	12.62	10.84	-
Warfarin	0.88	10.84	0.040	-	-
Prolin	0.66	12.62	-	-	-
Fumarin	0.18	-	-	-	-

	90 Percent or More Mortality				
Chemical	Compendium	Fumarin	Prolin	Warfarin	Pival
Diphacinone	0.85	0.42	0.55	0.09	6.39
Pival	5.86	2.87	5.46	5.65	-
Warfarin	0.26	0.09	0.10	-	-
Prolin	0.01	0.00	-	-	-
Fumarin	0.01	-	-	-	-

There was a statistically significant difference in the percentage of Pival bioassays meeting or exceeding the 90 percent mortality and 67 percent refusal requirement than all the other baits except Diphacinone (Table 8). Collectively, the indandione group (Diphacinone and Pival) significantly exceeded these criteria more than the hydroxycoumarin group (Warfarin, Prolin, and Fumarin). The Chi Square value of the proportional differences is 10.868 and is significant to a probability of less than 1:1000.

MORTALITY OVER 90 PERCENT

Over 77 percent of the rat bioassays resulted in a mortality of 90 percent or more. Diphacinone was the highest with 86 out of 105 trials (81.9 percent) resulting in the deaths of 18 or more rats per test. The number of tests of the other chemicals tested resulting in 90 percent mortality in descending order are: Warfarin, 125 out of 157 (79.6 percent); Prolin, 250 out of 321 (77.9 percent); Fumarin, 71 out of 92 (77.2 percent); and Pival, 46 out of 72 (63.9 percent).

RESULTS BY BAIT FORM

Wax blocks achieved the highest mean mortality (Table 6A). Although whole grains gave 100 percent kill in all tests, the sample was too small to assume results would follow a normal distribution. There was no statistical difference in the mean kill per test for wax blocks as compared to the other bait forms. However, there is a significant difference between meal and pellet baits ($P<0.05$). Although their means are almost identical (18.2 and 18.5 respectively) the sample sizes are large enough that a significant difference can be found between the means.

There is no significant difference between bait forms in mean survival per test. Bioassays with pellet bait forms resulted in a survival day rate of 165.2 days per tests, meal baits 169.6, and wax blocks 174.7.

Pellet baits were accepted considerably better than meal baits (Table 6C). The difference is significant to the five percent level.

Although 10.9 percent of the meal baits and 13.9 percent of the pellet bait bioassays met the 67 percent bait refusal and 90 percent or more mortality requirement, the difference between them is not statistically significant ($P>0.05$).

DISCUSSION

In keeping with the purpose of this paper, there will be very little discussion concerning the results. The data has been condensed so anyone can analyze the results and draw their own conclusions. However, it is clear that any of the five anticoagulant rodenticides are capable of achieving optimal control. The results also indicate that bait texture may be as important to control as any additive.

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